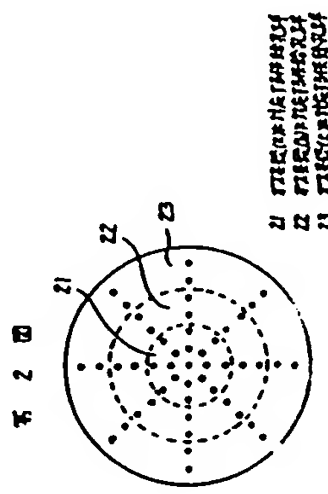
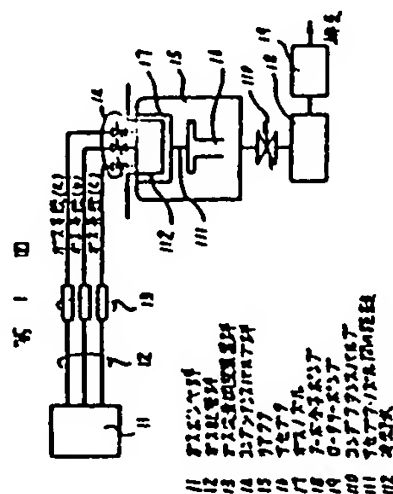


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HITACHI-KK. \*JO 3281-780-A  
30.03.90-JP-080739 (12.12.91) C23c-16/44 H011-21/20  
CVD appts. giving uniform thickness films - has concentric gas feed  
nozzles divided into radial gps. and facing susceptor  
C92-016059

Concentrically distributed gas feeding nozzles are faced to the  
susceptor in the reactor. The nozzles are divided into radial groups,  
where gas flow rate and conductance are controlled per each group  
individually.  
ADVANTAGE - Uniform film thickness is obtd.. (4pp  
Dwg.No.1,2/5)

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-1- (WPAT)

ACCESSION NUMBER  
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CVD appts. giving uniform thickness films - has  
concentric gas feed nozzles divided into radial gps.  
and facing susceptor

M13 U11 R46

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1

DERWENT CLASSES  
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NUMBER OF PATENTS  
PATENT FAMILY  
PRIORITY  
APPLICATION DETAILS  
INT'L. PATENT CLASS.  
ABSTRACT

J03281780-A 91.12.12 (9205) {JP}

90.03.30 90JP-080739

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C23C-016/44 H01L-021/20

(J03281780)

Concentrically distributed gas feeding nozzles are  
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individually.

ADVANTAGE - Uniform film thickness is obtd..

(4pp Dwg.No.1,2/5)

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IMAGE FILENAME

-2- (JAPIO)

ACCESSION NUMBER  
TITLE  
PATENT APPLICANT  
INVENTORS  
PATENT NUMBER  
APPLICATION DETAILS  
SOURCE

91-281780

CVD DEVICE

(2000510) HITACHI LTD

MITANI, KATSUHIKO, YANAGISAWA, HIROSHI

91.12.12 J03281780, JP 03-281780

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ABSTRACT

PURPOSE: To obtain a uniform gas flow in accordance  
with the pressure region of the gas in a wide range  
and the temp. range of a susceptor by providing a  
function which regulates the flow rate of gas and  
conductance at every group of a plurality of nozzles  
opposite to the susceptor.

CONSTITUTION: The gas supply system of a CVD device  
is constituted of a plurality of gas pipeline groups  
12, flow rate controlling device groups 13 and  
conductance valve groups 14. A gas nozzle 17 opposite  
to a susceptor 16 is equipped in a reactor 15. The  
gas supply face of the gas nozzle 17 has a plurality  
of aperture groups 21-23 for supplying gas, which are  
distributed in a concentric circular shape. These  
aperture groups are allotted to a plurality of kinds  
of gas system (a)-(c). Respective gas systems (a)-(c)

## ⑫ 公開特許公報(A) 平3-281780

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⑭ 発明の名称 CVD装置

⑮ 特 願 平2-80739

⑯ 出 願 平2(1990)3月30日

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⑳ 代 理 人 弁理士 小川 勝男 外1名

PTO 98-2891

S.T.I.C. Translations Branch

## 明 細 書

## 1. 発明の名称

CVD装置

## 2. 特許請求の範囲

1. CVD装置において、反応管内でサセプタと対向しているガス供給ノズル部を有し、該ノズルは同心円状に分布しており、且つ該半径方向に複数に分割したノズル群毎にガス流量及びコンダクタンスを制御できることを特徴とするCVD装置。

2. 複数の反応ガスを混合した後、上記同心円状に分布したノズルによりガスをサセプタ側に供給することを特徴とする請求項1記載のCVD装置。

3. 上記半径方向に複数に分割したノズル群毎に膜厚センサを具備しており、上記各ノズル群毎にガス流量及びコンダクタンスについてフィードバックをかけることが可能であることを特徴とする請求項1記載のCVD装置。

4. 上記半径方向に複数に分割したノズル群毎に

ガス圧センサを具備しており、上記各ノズル群毎にガス流量及びコンダクタンスについてフィードバックをかけることが可能であることを特徴とする請求項1記載のCVD装置。

## 3. 発明の詳細な説明

(産業上の利用分野)

本発明はCVD装置に係り、特に広い圧力範囲にわたって膜厚の面内均一性が良好な膜を成膜できる減圧CVD装置に関する。

(従来の技術)

供給律速系のCVD法においては、面内の膜厚均一性は試料表面における各反応ガス分圧の分布の影響を受けることが知られている。その対策として、例えばJournal of Crystal Growth 77 (1986) 151-156に記載されているように、試料表面すなわちサセプタに対して均一なガスフローが得られるように反応管形状の最適化を図り、試料面内における反応ガス分圧の均一化を達成している。

(発明が解決しようとする課題)

になる。

## 実施例2

実施例1では反応ガスの混合をガスノズルから流出させた後リアクタ内で行っている。本実施例では第4図に示すように各々のガス流量制御装置群42を通した後、ガス混合用配管43を通して反応ガスの混合を行つた。その際、ガスの逆流防止弁を適所に設置したことは言うまでもない。然る後、コンダクタンスバルブ群44及び第2図と同様のガスノズル45を通して反応ガスをリアクタ47に導入した。その他のCVD条件は実施例1と同じで同様な結果を得た。本実施例を用いると各反応ガス流量に対応させて各反応ガス用コンダクタンスバルブを調整する煩雑さが無くなる。この場合、全反応ガス流量のみに注目して各ガスノズル開孔部分に対応してコンダクタンスバルブを調整すれば良い。またサセプタ46とガスノズル45間の距離411が成膜特性に与える影響が小さい。

本実施例では全反応ガス流量と全反応ガスの圧

力に応じてガス供給系のコンダクタンスバルブ並びにサセプタとノズル間の距離を調整する必要がある。これらの調整をコンピュータ制御により自動化を図ることが可能であることは言うまでもない。

## 実施例3

上述した実施例では全反応ガス流量と全反応ガスの圧力に応じてガス供給系のコンダクタンスバルブ並びにサセプタとノズル間の距離等のパラメータを設定し開ループ制御で膜形成を行っている。本実施例では第5図に示すようにガスノズル55のガス供給面半径方向に複数の圧力センサ56及び複数の膜厚センサ57を具備させて非破壊で試料表面近傍のガス圧並びにCVD膜厚をモニタしてガス流量調整装置52並びにコンダクタンスバルブ54にフィードバックをかけてW膜を形成した。本実施例を用いて5インチウエファ上でのW膜厚分布を±0.5~1.0%以下に低減できた。

(発明の効果)

本発明を用いると、広範囲なガス圧力に対して

試料表面における反応ガスの分圧を均一にすることができるので膜厚の均一なCVD膜の形成が可能になる。本発明は選択CVD等、特に高真空下においてCVDを行う場合極めて有効である。

## 4. 図面の簡単な説明

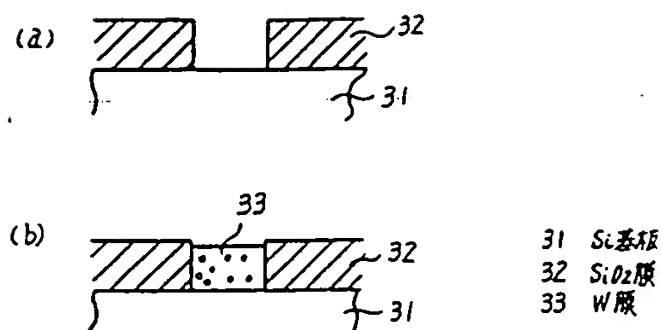
第1図は本発明の実施例1のCVD装置構成図、第2図は本発明のガスノズルのガス供給面側の一形状図、第3図(a)及び第3図(b)は実施例1の選択CVD説明図、第4図は実施例2におけるCVD装置構成図、第5図は実施例3のCVD装置構成図である。

11, 42, 51…ガス配管群、13, 42, 52…ガス流量調整装置群、14, 44, 54…コンダクタンスバルブ群、16, 46…サセプタ、15, 47…リアクタ、43…ガス混合用配管、17, 45, 55…ガスノズル、21…ガス系統(a)に対応する供給孔群、22…ガス系統(b)に対応する供給孔群、23…ガス系統(c)に対応する供給孔群、111, 411…サセプタとノズル間の距離、56…圧力センサ、57…膜厚セ

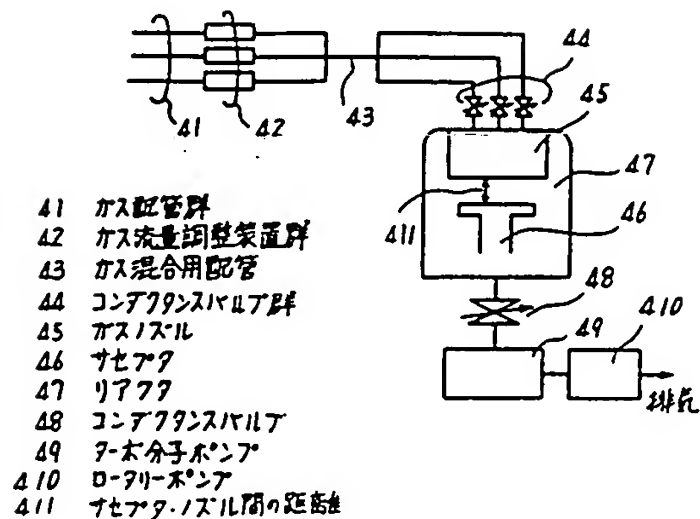
ンサ、510…制御用コンピュータ。

代理人 弁理士 小川勝男

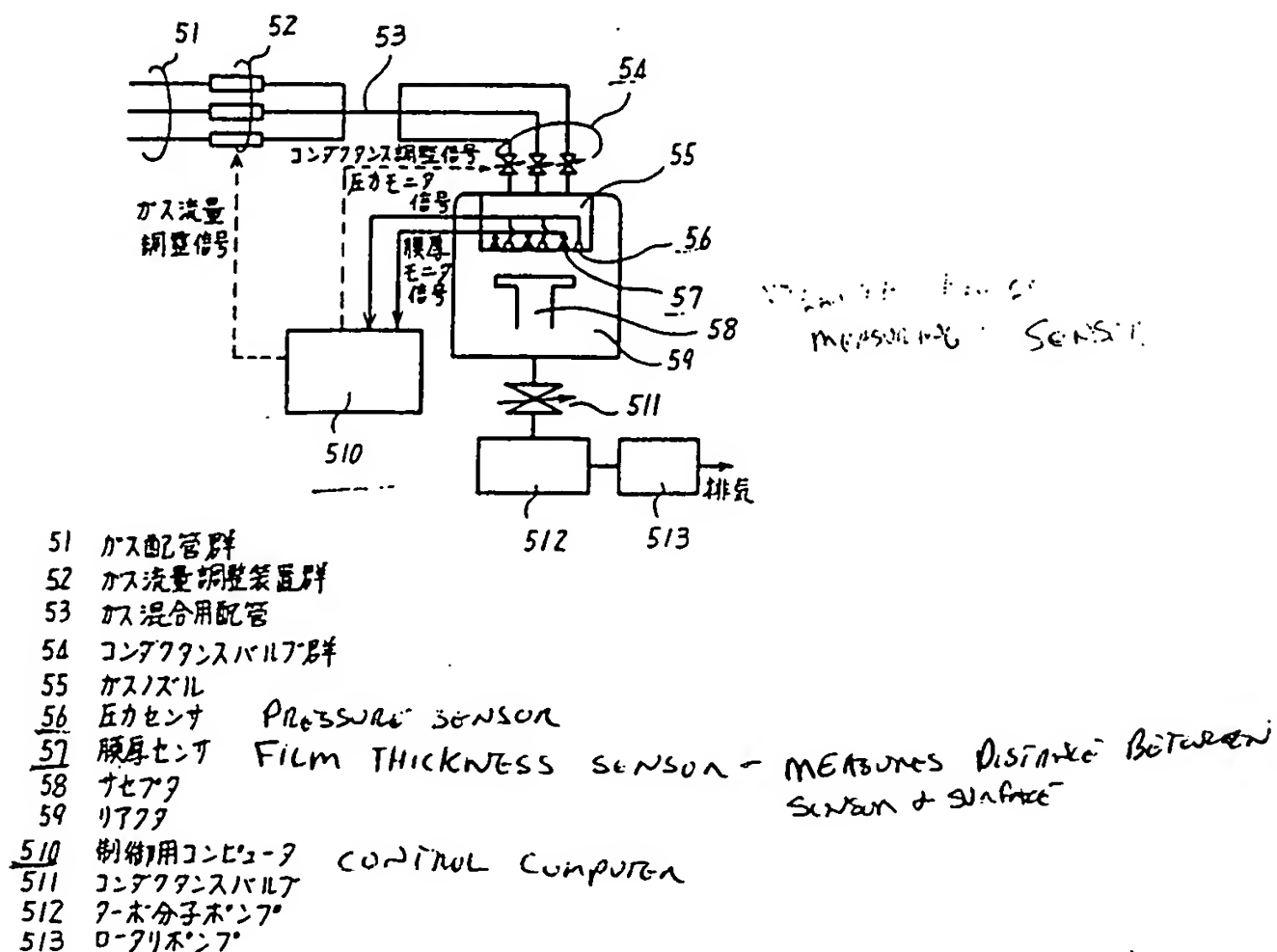
第 3 回



第 4 回



第 5 回



PTO 98-2891

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A CVD DEVICE  
[CVD sōchi]

Katsuhiko Mitani et al.

UNITED STATES PATENT AND TRADEMARK OFFICE  
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INVENTOR	(72) : MITANI, KATSUHIKO; YANAGISAWA, HIROSHI
APPLICANT	(71) : HITACHI, LTD.
TITLE	(54) : A CVD DEVICE
FOREIGN TITLE	[54A] : CVD SŌCHI

## Specification

### 1. Title of the Invention

A CVD device

### 2. Claims

1. A CVD device, said CVD device characterized as having a gas feeding nozzle part that faces a susceptor inside a reaction tube, and by the fact that said nozzles are distributed in a concentric state, and the gas feeding amount and conductance can be controlled for each one of several nozzle groups that are distributed in the radial direction.

2. A CVD device according to Claim 1, characterized by the fact that, after multiple reaction gases have been blended, the gas is supplied to the susceptor side from the aforesaid concentrically distributed nozzles.

3. A CVD device according to Claim 1, characterized by the fact that a film thickness sensor is provided for each of the aforesaid multiple nozzle groups distributed in the radial direction, allowing feedback to be provided with regard to the gas flow amount and conductance for each of the aforesaid nozzle groups.

4. A CVD device according to Claim 1, characterized by the fact that a gas pressure sensor is provided for each one of the aforesaid multiple nozzle groups distributed in the radial direction, allowing feedback to be performed with regard to the gas flow amount and conductance for each of the aforesaid nozzle groups.



### 3. Detailed Explanation of the Invention

#### (Industrial Field of Application)

The present invention relates to a CVD device, in particular an *in vacuo* CVD device that can form a good film having in-plane uniformity within a wide range of pressures.

#### (Prior Art)

In feed rate determining-type CVD methods, it is known that the in-plane uniformity of film thickness is subject to the effects of the distribution of the partial pressures of each reaction gas on the sample surface. As countermeasures against this, for example, as specified in the Journal of Crystal Growth 77 (1986), 151-156, the optimization of the reaction tube formed is planned so as to obtain a uniform gas flow with regard to the sample surface, i.e., the susceptor, and the equalization of reaction gas partial pressure within the sample flame is achieved.

#### (Problems that the Invention is to Solve)

The geometric equalization of the gas flow due to the aforesaid reaction tube formed, susceptor formed, and distance between the two is effective only under specified conditions, and is susceptible to the effects of total gas pressure and susceptor temperature, and thus cannot be said to be universal. The present invention has the purpose of offering a CVD device that is able to obtain a uniform gas flow with regard to a wide range of gas pressure regions and susceptor temperature regions.

#### (Means of Solving the Problems)

The aforesaid problems are solved by means of a CVD device, said

CVD device characterized as having a gas feeding nozzle part that faces a susceptor inside a reaction tube, and by the fact that said nozzles are distributed in a concentric state, and the gas feeding amount and conductance can be controlled for each one of several nozzle groups that are distributed in the radial direction.

(Operation)

The distribution of gas partial pressure on a susceptor that is placed perpendicular to the flow of gas in a cylindrical reaction tube is a concentric distribution. Thus, by using a CVD device that uses gas nozzles that are distributed concentrically with regard to the susceptor, and that by adjusting the gas flow amount and conductance with regard to each of multiple concentric nozzle groups is able to correct and equalize the distribution of the aforesaid gas partial pressure, it is possible to equalize the gas pressure on the sample face in a wide range of gas pressures and a wide range of temperature regions. As a result, the in-plane distribution of the CVD film thickness is improved.

(Working Examples)

Working Example 1

Working Example 1 of the present invention is explained beginning with the schematic drawing of a CVD device shown in Figure 1 and the form drawing of the gas nozzle feeding face side shown in Figure 2. The CVD device is basically composed of a gas feeding system, a reactor, and a gas exhaust system. The gas feeding system consists of a gas cylinder (11), multiple gas piping groups (12) (in this case 3 systems), and flow control device groups (13) and conductance valve groups (14)

corresponding to said pipings.

A heatable susceptor (16) and corresponding gas nozzle (17) are placed in the reactor (15). The gas feeding face of the gas nozzles has a gas feeding hole part composed of multiple fine holes arranged in a circular and concentric form as shown in Figure 2. The gas feeding hole groups that are arranged concentrically are allotted into 3 types of gas systems (a), (b), and (c) and are classified into feeding hole group (21) corresponding to gas system (a), feeding hole group (22) corresponding to gas system (b), and feeding hole group (23) corresponding to gas system (c). Flow amount control and conductance control are performed independently for the gas that flows through each of said feeding hole groups. The exhaust system is composed of a turbomolecular pump (18) and rotary pump (19) and adjusts the pressure in the reactor (15) using a conductance valve (110).

In the gas system (a) 2 SCCM of  $WF_6$ , in the gas system (b) 1 SCCM of  $SiH_4$ , and in the gas system (c) 10 SCCM of  $H_2$  were passed through the gas flow amount control device (13) (mass controller: Nippon Tairan FC260) and conductance valve (14) from the aforesaid gas nozzle (17) into a cold wall-type reactor. The susceptor (16) was controlled so as to be within a range of 280 to 320°C by resistance heating. The distance (111) between the susceptor (16) and gas nozzle (17) was made 5 to 15 mm. The gas exhaust system used a turbomolecular pump (Arukateru [as transliterated] 5150, gas exhaust speed 140 l/s) (18) and a rotary pump (19) as an auxiliary pump. The total gas pressure range at this time was 0.05 to 0.1 Torr.

When a Si substrate (5 inches in diameter) was inserted into the

aforesaid CVD device as a test material, a reduction reaction of  $WF_6$  caused by  $SiH_4$  occurred, and a W film was deposited. It is known that the thickness of the W film at this time is approximately proportional to the  $SiH_4$  gas pressure on the sample surface. When  $SiH_4$  gas was allowed to flow for 1 min, an average film thickness of 3320 Å with an in-plane distribution of  $\pm 3\%$  or less was formed on a 5-inch diameter Si wafer.

In addition, forced cooling was performed on said nozzle by the circulation of cooling water (112). By this means, only the example on the susceptor was heated, so the W deposition reaction was limited to the sample surface. As a result, a deposition reaction of W occurred selectively with regard to Si (31), which was partially exposed from the  $SiO_2$  film (32) as shown in Figure 3(a). Using this technique, selective hole fill-in by means of a W film (33) as shown in Figure 3(b) becomes possible.

#### Working Example 2

In Working Example 1, the mixture of reaction gases was performed inside the reactor after the gases were discharged from the gas nozzle. In this working example, after passing through the respective gas flow control device groups (42), as shown in Figure 4, the gases were passed through the gas blending tubes (43) and blending of the reaction gases was performed. In this process, needless to say, gas flow check valves were installed in suitable locations. Next, the reaction gas was passed through the conductance valve group (44) and a gas nozzle (45) similar to that shown in Figure 2 and introduced into the reactor (47). The other CVD conditions were the same as those in Working Example 1, and

similar results were obtained. Using this working example, the complexity of adjusting the conductance valve for each reaction gas in response to each reaction gas flow amount is eliminated. In this case, the conductance can be adjusted in correspondence with each gas nozzle opening part considering only the total reaction gas flow amount. Moreover, the effects of the distance (411) between the susceptor (46) and gas nozzle (45) on the film formation characteristics are small.

In this working example, it is necessary to adjust the conductance valve of the gas feeding system and the distance between the susceptor and the nozzle in accordance with the total reaction gas flow amount and total reaction gas pressure. Needless to say, this adjustment can be automated by means of computer control.

#### Working Example 3

In the working examples described above, film formation is performed by open-loop control whereby parameters such as the conductance valve in the gas feeding system and the distance between the susceptor and nozzle are set in accordance with the total reaction gas flow amount and total reaction gas pressure. In the present working example, as shown in Figure 5, multiple pressure sensors (56) and multiple film thickness sensors (57) are installed in the radial direction of the gas feeding surface of the gas nozzle (55), and the gas pressure in the vicinity of the sample surface and the CVD film thickness are non-destructively monitored, providing feedback to the gas flow amount control device (52) and conductance valve (54) to form a W film. Using this working example, it was possible to reduce the W film thickness distribution on a 5-inch diameter wafer to  $\pm 0.5$  to 1.0% or

less.

#### (Effects of the Invention)

Using the present invention, it is possible to equalize the distribution of reaction gas on the sample surface with regard to a wide range of gas pressures, so that the formation of a CVD film having uniform film thickness becomes possible. The present invention is extremely effective when selective CVD, etc. and particularly CVD is performed in a high-level vacuum.

#### 4. Brief Explanation of the Figures

Figure 1 is a structural diagram of a CVD device in Working Example 1 of the present invention, Figure 2 is a formal diagram of the gas feeding surface side of the gas nozzle in the present invention, Figure 3(a) and Figure 3(b) are diagrams explaining selective CVD in Working Example 1, Figure 4 is a structural diagram of the CVD device in Working Example 2, and Figure 5 is a structural diagram of the CVD device in Working Example 3.

11, 42, 51: gas piping group, 13, 42, 52: gas flow amount adjustment device group, 14, 44, 54: conductance valve group, 16, 46: susceptor, 15, 47: reactor, 43: gas mixing tube, 17, 45, 55: gas nozzle, 21: feeding hole group corresponding to gas system (a), 22: feeding hole group corresponding to gas system (b), 23: feeding hole group corresponding to gas system (c), 111, 411: distance between susceptor and nozzle, 56: pressure sensor, 57: film thickness sensor, 510: control computer

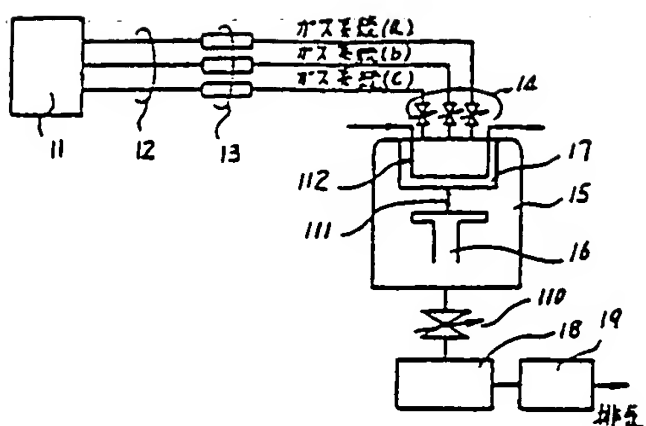


Figure 1

gas system (a)

gas system (b)

gas system (c)

[bottom right:] exhaust

11: gas canister group

12: gas piping group

13: gas flow amount adjustment device group

14: conductance valve group

15: reactor

16: susceptor

17: gas nozzle

18: turbomolecular pump

19: rotary pump

110: conductance valve

111: distance between susceptor and nozzle

112: cooling water

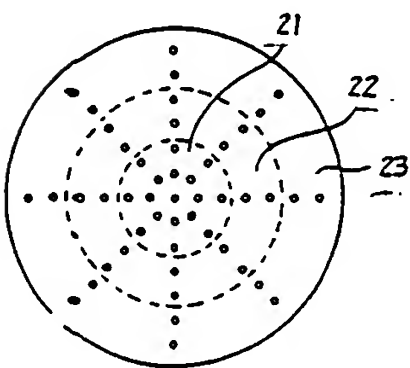


Figure 2

21: feeding hole group corresponding to gas system (a)

22: feeding hole group corresponding to gas system (b)

23: feeding hole group corresponding to gas system (c)

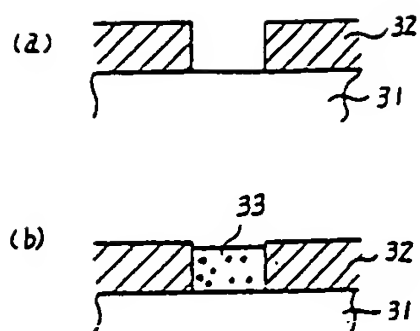


Figure 3  
 31: Si substrate  
 32: SiO<sub>2</sub> film  
 33: W film

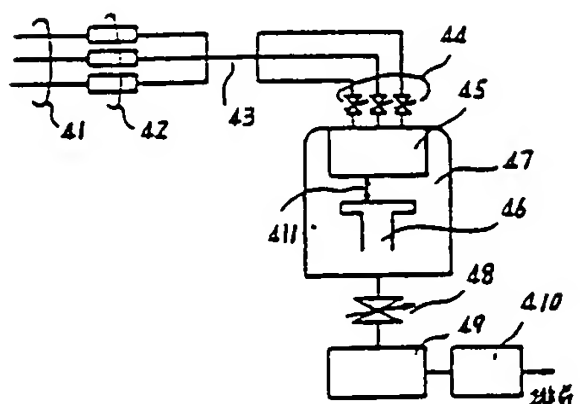


Figure 4  
 41: gas piping group  
 42: gas flow amount adjustment device group  
 43: gas mixing tube  
 44: conductance valve group  
 45: gas nozzle  
 46: susceptor  
 47: reactor  
 48: conductance valve  
 49: turbomolecular pump  
 410: rotary pump  
 411: distance between susceptor and nozzle



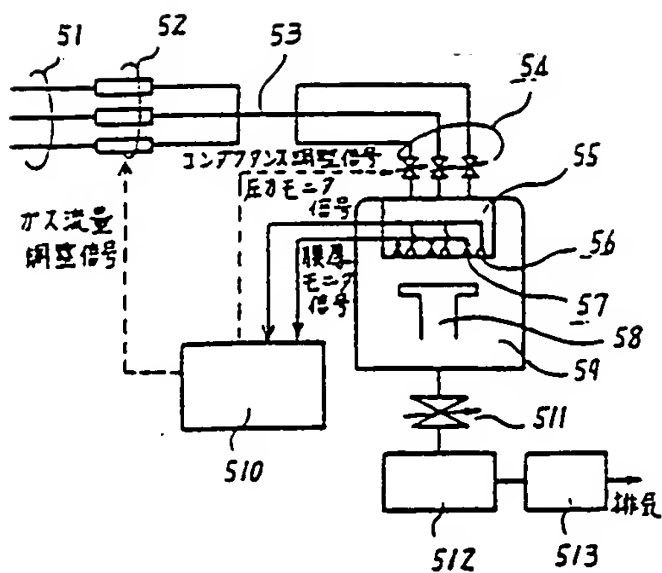


Figure. 5

[under 51:] gas flow amount adjustment signal

[under 53:] conductance adjustment signal

pressure monitor signal

film thickness monitor signal

[right of 513:] exhaust

51: gas piping group

52: gas flow amount adjustment device group

53: gas mixing tube

54: conductance valve group

55: gas nozzle

56: pressure sensor

57: film thickness sensor

58: susceptor

59: reactor

510: control computer

511: conductance valve

512: turbomolecular pump

513: rotary pump